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(71) Applicant: E.I. DU PONT DE NEMOURS AND COMPANY [US/US]; 1007 Market Street, Wilmington, DE 19898 (US).

(72) Inventors: BIVENS, Donald, Bernard; 210 West Locust Lane, Kennett Square, PA 19348-1635 (US). MINOR, Barbara, Haviland; 233 Green Haven Drive, Elkton, MD 21921-7619 (US). SIEVERT, Allen, Capron; 215 Rhett Lane, Elkton, MD 21921-2059 (US).

(74) Agent: KING, Karen, K.; E.I. du Pont de Nemours and Company, Legal/Patent Records Center, 1007 Market Street, Wilmington, DE 19898 (US).

(54) Title: REFRIGERANTS BASED ON HYDROFLUOROETHER OF FLUOROETHER

(57) Abstract

Compositions comprising a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine wherein said compositions are useful as refrigerants, cleaning agents, aerosol propellants, heat transfer media, gaseous dielectrics, fire extinguishing agents, expansion agents for polymers such as polyolefins and polyurethanes, and as power cycle working fluids are described.

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Refrigerants based on hydrofluoroether or fluoroether

FIELD OF INVENTION

This invention relates to the use of a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine as a refrigerant, an aerosol propellant, a cleaning agent, a heat transfer media, a gaseous dielectric, a fire extinguishing agent, an expansion agent for polymers such as polyolefins and polyurethanes, and as a power cycle working fluid.

More particularly, this invention relates to the use of a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine as a highly effective and potentially environmentally safe refrigerant in refrigeration equipment that use centrifugal compression and in particular small turbine centrifugal compression.

BACKGROUND OF THE INVENTION

Mechanical refrigeration is primarily an application of thermodynamics wherein a cooling medium, such as a refrigerant, goes through a cycle so that it can be recovered for reuse. Commonly used cycles include vapor-compression, absorption, steam-jet or steam-ejector, and air.

The equipment used in a vapor-compression cycle includes an evaporator, a compressor, a condenser, a liquid storage receiver and an expansion valve. Liquid refrigerant enters the evaporator through an expansion valve, and the liquid refrigerant boils in the evaporator at a low temperature to form a gas to produce cooling. The low pressure gas enters a compressor where the gas is compressed to raise its pressure and temperature. The high pressure gaseous

refrigerant then enters the condenser in which the refrigerant condenses and discharges its heat to the environment. A receiver collects the condensed high pressure liquid refrigerant, and the refrigerant goes to the expansion valve through which the liquid expands from the high pressure level in the condenser to the low pressure level in the evaporator.

There are various types of compressors that may be used in refrigeration applications. Compressors can be generally classified as reciprocating, rotary, jet, centrifugal, or axial-flow, depending on the mechanical means to compress the fluid, or as positive-displacement or dynamic, depending on how the mechanical elements act on the fluid to be compressed.

A centrifugal compressor uses rotating elements to accelerate the refrigerant radially, and typically includes an impeller and diffuser housed in a casing. Centrifugal compressors usually take fluid in at an impeller eye, or central inlet of a circulating impeller, and accelerate it radially outwardly. Some static pressure rise occurs in the impeller, but most of the pressure rise occurs in the diffuser section of the casing, where velocity is converted to static pressure. Each impeller-diffuser set is a stage of the compressor. Centrifugal compressors are built with from 1 to 12 or more stages, depending on the final pressure desired and the volume of refrigerant to be handled.

The pressure ratio, or compression ratio, of a compressor is the ratio of absolute discharge pressure to the absolute inlet pressure. Pressure delivered by a centrifugal compressor is practically constant over a relatively wide range of capacities.

Positive displacement compressors draw vapor into a chamber, and the chamber decreases in volume to compress the vapor. After being compressed, the vapor is forced from the chamber by further decreasing the volume of the chamber to zero or nearly zero. A positive displacement compressor can build up a pressure which is limited only by the volumetric efficiency and the strength of the parts to withstand the pressure.

Unlike a positive displacement compressor, a centrifugal compressor depends entirely on the centrifugal force of the high speed impeller to compress the vapor passing through the impeller. There is no positive displacement, but rather what is called dynamic-compression.

The pressure a centrifugal compressor can develop depends on the tip speed of the impeller. Tip speed is the speed of the impeller measured at its tip and is related to the diameter of the impeller and its revolutions per minute. The

capacity of the centrifugal compressor is determined by the size of the passages through the impeller. This makes the size of the compressor more dependent on the pressure required than the capacity.

Because of its high speed operation, a centrifugal compressor is fundamentally a high volume, low pressure machine. A centrifugal compressor works best with a low pressure refrigerant, such as trichlorofluoromethane (CFC-11) or 1,2,2-trichlorotrifluoroethane (CFC-113).

Large centrifugal compressors typically operate at 3000 to 7000 revolutions per minute (rpm). Small turbine centrifugal compressors are designed for high speeds, from about 40,000 to about 70,000 (rpm), and have small impeller sizes, typically less than 0.15 meters.

A two-stage impeller is common for many conditions. In operation, the discharge of the first stage impeller goes to the suction intake of a second impeller. Each stage can build up a compression ratio of about 4 to 1, that is, the absolute discharge pressure can be four times the absolute suction pressure.

A proposed world-wide reduction in the production of fully halogenated chlorofluorocarbons such as CFC-11 and CFC-113 has developed a need for alternative, more environmentally acceptable products.

SUMMARY OF THE INVENTION

Accordingly, this invention relates to a refrigerant that may be used in centrifugal compressors designed for the refrigerant 1,1,2-trichlorotrifluoroethane (CFC-113) that performs similarly to CFC-113.

This invention also relates to a refrigerant that has a lower ozone depletion potential than CFC-113.

Surprisingly and unexpectedly it was found that the advantages and improvements discussed above, and others, are achieved by the use of a refrigerant containing a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine. It was found that these compositions can be used as a refrigerant in centrifugal compression refrigeration equipment designed for CFC-113 while achieving operating performances comparable to CFC-113.

The present invention further relates to the discovery that use of a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine may be used as an aerosol propellant, a cleaning agent, a heat transfer media, a gaseous dielectric, a fire extinguishing agent, an expansion agent for polymers such as polyolefins and polyurethanes, or as a power cycle working fluid.

The present invention is particularly useful in small turbine centrifugal compressors which can be used in auto and window air conditioning or heat pump as well as other applications.

DETAILED DESCRIPTION

The present invention relates to the use of a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine as a refrigerant for use in centrifugal compression refrigeration equipment.

Examples of these compounds include the following:

1. 1-(difluoromethoxy)-1,1,2-trifluoroethane ($CHF_2OCF_2CH_2F$, 245caEαβ, boiling point = 40°C);
2. 1-(difluoromethoxy)-1,2,2-trifluoroethane ($CHF_2OCHFCHF_2$, 245eaE, boiling point = 53.0°C);
3. 1,1'-oxybis(1,2,2,2-tetrafluoro)ethane ($CF_3CHFOCHFCF_3$, 338meeEβγ, boiling point = 50.0°C);
4. 2-(difluoromethoxy)-1,1,1,3,3,3-hexafluoropropane ($(CF_3)_2CHOCHF_2$, 338mmzEβγ, boiling point = 42.1°C);
5. 3-(difluoromethoxy)-1,1,1,2,2,3-hexafluoropropane ($CHF_2OCHFCF_2CF_3$, 338peEγδ, boiling point = 44.5°C);
6. 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)-ethane ($CHF_2CH_2OCF_2CF_3$, 347mcfEβγ, boiling point = 45.4°C);

7. 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane ($CHF_2OCH_2CF_2CF_3$, 347mcfEγδ, boiling point = 45.9°C);
8. 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane ($CH_3OCF_2CHFOCF_3$, 356mecE2αβγδ, boiling point = 58.0°C);
9. 1,1,1,2,3,3-hexafluoro-3-methoxypropane ($CH_3OCF_2CHFCF_3$, 356mecEγδ, boiling point = 56.0°C);
10. 1,1,1,3,3,3-hexafluoro-2-methoxypropane ($(CF_3)_2CHOCH_3$, 356mmzEβγ, boiling point = 50.0°C);
11. 1,1,1,2,2-pentafluoro-3-methoxypropane ($CF_3CF_2CH_2OCH_3$, 365sfEγδ, boiling point = 47.5°C);
12. 1-ethoxy-1,1,2,2-tetrafluoroethane ($C_2H_5OCF_2CHF2$, 374pcEβγ, boiling point = 56.0°C);
13. 2-ethoxy-1,1,1-trifluoroethane ($C_2H_5OCH_2CF_3$, 383mEβγ, boiling point = 49.9°C);
14. 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)propane ($CF_3CF_2CF_2OCHFCF_3$, 42-11meEγδ, boiling point = 40.8°C);
15. 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane ($C_2H_5OCF(CF_3)_2$, 467mmyEβγ, boiling point = 45.5°C);
16. 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane ($C_2H_5OCF_2CF_2CF_3$, 467sfEγδ, boiling point = 51.5°C);
17. $C_4F_9OCH_3$ isomers including 1,1,1,2,2,3,3,4,4,-nonafluoro-4-methoxy-butane ($CH_3OCF_2CF_2CF_2CF_3$), 1,1,1,2,3,3,-hexafluoro-2-(trifluoromethyl)-3-methoxy-propane ($CH_3OCF_2CF(CF_3)_2$), 1,1,1,3,3,3-hexafluoro-2-methoxy-2-(trifluoromethyl)-propane ($CH_3OC(CF_3)_3$), and 1,1,1,2,3,3,4,4,4-nonafluoro-2-methoxy-butane ($CH_3OCF(CF_3)CF_2CF_3$), approximate isomer boiling point = 60°C;
18. $C_4F_9OC_2H_5$ isomers including 1,1,1,2,2,3,3,4,4-nonafluoro-4-ethoxy-butane ($CH_3CH_2OCF_2CF_2CF_2CF_3$), 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-ethoxy-propane ($CH_3CH_2OCF_2CF(CF_3)_2$), 1,1,1,3,3,3-hexafluoro-2-ethoxy-2-(trifluoromethyl)-propane ($CH_3CH_2OC(CF_3)_3$, and 1,1,1,2,3,3,4,4,4-nonafluoro-2-ethoxy-butane ($CH_3CH_2OCF(CF_3)CF_2CF_3$, approximate isomer boiling point = 73°C;
19. 1,1,2,2-tetrafluorocyclobutane (cyclo-$CF_2CF_2CH_2CH_2$-, c354cc, boiling point = 50.0°C);
20. perfluorocyclohexane (cyclo-C_6F_{12}, c51-12c, boiling point = 52.8°C);

21. 1,1,2,2,3,4-hexafluoro-3,4-bis(trifluoromethyl)cyclobutane (cyclo-$CF(CF_3)CF(CF_3)CF_2CF_2$-, c51-12mym, boiling point = 44.7°C);
22. perfluorohexane (C_6F_{14}, FC-51-14, boiling point = 57.2°C);
23. perfluoro-n-methylmorpholine ($C_5F_{11}NO$, boiling point = 50.0°C);
24. 2-(difluoromethyl)-1,1,1,2,3,3-hexafluoropropane ($CHF_2CF(CF_3)CHF_2$. HFC-338mpy, boiling point = 56.0°C);
25. 1,1,2,2,3,3,4,4-octafluorobutane ($CHF_2CF_2CF_2CHF_2$, HFC-338pcc, boiling point = 44.4°C);
26. 1,1,2,2,4-hexafluorobutane ($CF_3CF_2CH_2CH_2F$, HFC-356mcf, boiling point = 44.0°C);
27. 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane ($(CF_3)_2CFCF_2CHF_2$, HFC-42-11mmyc, boiling point = 45.5°C);
28. 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane ($CHF_2CF_2CF_2CF_2CF_3$, HFC-42-11p, boiling point = 45.0°C);
29. 1,1,1,2,3,4,4,5,5,5-decafluoropentane ($CF_3CHFCHFCF_2CF_3$, HFC-43-10mee, boiling point = 53.6°C);
30. 1,1,1,2,2,3,3,5,5,5-decafluoropentane ($CF_3CH_2CF_2CF_2CF_3$, HFC-43-10mf, boiling point = 47.0°C);
31. 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane ($(CF_3)_2CHCH_2CF_3$, HFC-449mmzf, boiling point = 52.5°C);
32. 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluorohexane ($CHF_2(CF_2)_4CF_3$, HFC-52-13, boiling point = 70.0°C);
33. 1,1,1,2,2,5,5,5-octafluoro-4-(trifluoromethyl)pentane ($(CF_3)_2CHCH_2CF_2CF_3$, HFC-54-11mmzf, boiling point = 64.0°C);
34. nonafluoro-tert-butanol ($(CF_2)_3COH$, boiling point = 45.0°C).

1-(difluoromethoxy)-1,1,2-trifluoroethane (245caEαβ, $CHF_2OCF_2CH_2F$, CAS Reg. No. [69948-24-9]) has been prepared by hydrogenation of 2-chloro-1,1,2-trifluoroethyl difluoromethyl ether at 200°C over a palladium catalyst as disclosed by Bagnall, et. al. in J. Fluorine Chem., Vol. 13 pages 123-140 (1979).

1-(difluoromethoxy)-1,2,2-trifluoroethane (245eaE, $CHF_2OCHFCHF_2$, CAS Reg. No. [60113-74-8]) has been prepared by hydrogenation of 1,2-dichloro-1,22-trifluoroethyl difluoromethyl ether at a temperature range of 200-250°C using a palladium on charcoal catalyst as disclosed by Bell, et. al. U. S. Patent 4,149,018.

1,1'-Oxybis(1,2,2,2-tetrafluoro)ethane (338meeEβγ, $CF_3CHFOCHFCF_3$, CAS Reg. No. [67429-44-1]) has been prepared by the reaction of diethylaminosulfur trifluoride with trifluoroacetaldehyde as disclosed by Siegemund Ger. Offen. 2,656,545.

2-(Difluoromethoxy)-1,1,1,3,3,3-hexafluoropropane (338mmzEβγ, $(CF_3)_2CHOCHF_2$, CAS Reg. No. [26103-08-2]) has been prepared by fluorination of 2-(dichloromethoxy)-1,1,1,3,3,3-hexafluoropropane with an antimony trifluoride/antimony pentachloride mixture as disclosed by Speers, et. al. in J. Med. Chem., Vol. 2, pp. 593-595 (1971).

3-(Difluoromethoxy)-1,1,1,2,2,3-hexafluoropropane (338peEγδ, $CHF_2OCHFCF_2CF_3$, CAS Reg. No. [60598-11-0]) may be prepared from pentafluoropropanol, chlorodifluoromethane, chlorine, and cobalt(III)fluoride by a process similar to that used for $CHF_2OCHFCF_2CHF_2$ and disclosed by Bagnall, et. al. in J. Fluorine Chem., Vol. 11, pp. 93-107 (1978).

3-Difluoromethoxy-1,1,1,2,2-pentafluoropropane (347mcfEγδ, $CHF_2OCH_2CF_2CF_3$, CAS Reg. No. [56860-81-2]) has been prepared by the reaction of 2,2,3,3,3-pentafluoro-1-propanol with chlorodifluoromethane in the presence of aqueous sodium hydroxide as disclosed by Regan in U.S. Patent 3,943,256.

1,1,2-Trifluoro-1-methoxy-2-(trifluoromethoxy)ethane (356mecE2αβγδ, $CH_3OCF_2CHFOCF_3$, CAS Reg. No. [996-56-5]) may be prepared by the reaction of trifluoromethyl trifluorovinyl ether with methanol as disclosed by Tumanova, et. al. in Zh. Obshch. Khim., Vol. 35, pp. 399-400 (1965).

1,1,1,2,3,3-Hexafluoro-3-methoxypropane (356mecEγδ, $CH_3OCF_2CHFCF_3$, CAS Reg. No. [382-34-3]) has been prepared by the reaction of methanol with hexafluoropropene as disclosed by England, et. al. in J. Fluorine Chem., Vol. 3, pp. 63-8 (1973/74).

1,1,1,3,3,3-Hexafluoro-2-methoxypropane (356mmzEβγ, $(CF_3)_2CHOCH_3$, CAS Reg. No. [13171-18-1]) has been prepared by the reaction of 1,1,1,3,3,3-hexafluoroisopropanol with dimethyl sulfate in the presence of aqueous sodium hydroxide as disclosed by Gilbert, et. al. in U. S. Patent 3,346,448.

1,1,1,2,2-Pentafluoro-3-methoxypropane (365sfEγδ, $CF_3CF_2CH_2OCH_3$, CAS Reg. No. [378-16-5]) has been prepared by the reaction of 2,2,3,3,3-pentafluoro-1-propanol with dimethyl sulfate in the presence of aqueous potassium hydroxide as disclosed by Terrell in U. S. Patent 3,896,177.

1-Ethoxy-1,1,2,2-tetrafluoroethane (374pcEβγ, $C_2H_5OCF_2CHF_2$, CAS Reg. No. [512-51-6]) has been prepared by the reaction of ethanol with tetrafluoroethylene as reported by Park, et. al. in J. Am. Chem. Soc., Vol.73, pp. 1329-1330 (1951).

2-Ethoxy-1,1,1-trifluoroethane (383mEβγ, $C_2H_5OCH_2CF_3$, CAS Reg. No. [461-24-5]) has been prepared by reaction of sodium trifluoroethoxide with ethyl bromide as disclosed by Henne, et. al. in J. Am. Chem. Soc., Vol. 72, pp. 4378-4380 (1950).

1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)propane (42-11meEγδ, $CF_3CF_2CF_2OCHFCF_3$, CAS Reg No. [3330-15-2]) has been prepared by heating $CF_3CF_2CF_2OCF(CF_3)CO_2$-Na+ in ethylene glycol as disclosed by Selman and Smith in French Patent No. 1,373,014 (Chemical Abstracts 6213047g).

3-Ethoxy-1,1,1,2,2,3,3-heptafluoropropane (467sfEγδ, $C_2H_5OCF_2CF_2CF_3$, CAS Reg. No. [22052-86-4]) has been prepared by reaction of pentafluoropropionyl fluoride with potassium fluoride and diethyl sulfate in N,N-dimethylformamide as disclosed by Scherer, et. al. in Ger. Offen. 1,294,949.

2-Ethoxy-1,1,1,2,3,3,3-heptafluoropropane (467mmyEβγ, $C_2H_5OCF(CF_3)_2$, CAS. Reg. No. [22137-14-0]) may be prepared by the reaction of ethyl iodide with a mixture of hexafluoroacetone and potassium fluoride as disclosed in French Patent 1,506,638.

1,1,2,2-Tetrafluorocyclobutane (HFC-C-354cc, cyclo-$CF_2CF_2CH_2CH_2$-, CAS Reg. No. [374-12-9]) has been prepared by reacting ethylene and tetrafluoroethylene at 150°C as disclosed by Coffman, et. al. in J. Am. Chem. Soc., Vol. 71, pp. 490-496 (1949).

Perfluorocyclohexane (FC-C-51-12, cyclo-C_6F_{12}, CAS Reg. No. [355-68-0]) has been prepared by the reaction of fluorine with cyclohexane as disclosed by Adcock, et. al. in J. Am. Chem. Soc., Vol. 103, pp. 6937-6947 (1981).

2-(Difluoromethyl)-1,1,1,2,3,3-hexafluoropropane (HFC-338mpy, $CHF_2CF(CF_3)CHF_2$, CAS Reg. No. [65781-21-7]) has been prepared by the reaction of isobutane with cobalt(III) fluoride as disclosed by Burdon, et. al. in J. Fluorine Chem., Vol. 10, 523-540 (1977).

1,1,2,2,3,3,4,4-octafluorobutane (HFC-338pcc, $CHF_2CF_2CF_2CHF_2$) has been prepared by refluxing the potassium salt of perfluoroadipic acid in ethylene glycol as disclosed by Hudlicky, et. al. in J. Fluorine Chemistry, Vol. 59, pp. 9-14 (1992).

1,1,1,2,2,4-Hexafluorobutane (HFC-356mcf, $CF_3CF_2CH_2CH_2F$, CAS Reg. No. [161791-33-9]) may be prepared by the reaction of the p-toluene sulfonate of 3,3,4,4,4-pentafluoro-1-butanol with potassium fluoride following the procedure disclosed by Cohen in J. Org. Chem., Vol. 26, pp. 4021-4026 (1961).

1,1,1,2,3,3,4,4-Octafluoro-2-(trifluoromethyl)butane (HFC-42-11mmyc, $(CF_3)_2CFCF_2CHF_2$, CAS Reg. No. [1960-20-9]) has been prepared by reducing 1-iodo-1,1,2,2,3,4,4,4-octafluoro-3-(trifluoromethyl)butane with zinc in the presence of sulfuric acid as disclosed by Chambers, et. al. in Tetrahedron, Vol. 20, pp. 497-506 (1964).

1,1,1,2,2,3,3,4,4,5,5-Undecafluoropentane (HFC-42-11p, $CHF_2CF_2CF_2CF_2CF_3$, CAS Reg. No. [375-61-1]) has been prepared by treating 1-iodo-1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane with alcoholic potassium hydroxide at elevated temperature as disclosed by Haszeldine in J. Chem. Soc. pp. 3761-3768 (1953).

1,1,1,2,2,3,3,5,5,5-Decafluoropentane (HFC-43-10mf, $CF_3CH_2CF_2C_2F_5$, CAS Reg. No. [755-45-3]) has been prepared by the reaction of antimony dichlorotrifluoride with 1-iodo-1,1,3,3,4,4,5,5,5-nonafluoropentane (prepared in turn from vinylidene fluoride and 1-iodo-heptafluoropropane) as disclosed by Hauptschein, et. al. in J. Am. Chem. Soc., Vol. 82, pp. 2868-2871 (1960).

1,1,1,4,4,4-Hexafluoro-2-(trifluoromethyl)butane (HFC-449mmzf, $(CF_3)_2CHCH_2CF_3$, CAS Reg. No. [367-53-3]) has been prepared by the reaction of 2-iodo-3-trifluoromethyl-hexafluoro-2-butene with hydrogen over palladium catalyst as disclosed by Evans, et. al. in J. Chem. Soc. Perkin Transactions I pp.649-654 (1973).

1,1,1,2,2,3,3,4,4,5,5,6,6-Tridecafluorohexane (HFC-52-13p, $CHF_2(CF_2)_4CF_3$, CAS Reg. No. [355-37-3]) may be prepared by the reduction of 1-iodo-perfluorohexane with zinc in ethylene glycol as reported by Hudlicky, et. al. in J. Fluorine Chem., Vol. 59, pp. 9-14 (1992).

1,1,1,2,2,5,5,5-Octafluoro-4-(trifluoromethyl)pentane (HFC-54-11mmzf, $(CF_3)_2CHCH_2CF_2CF_3$, CAS Reg. No. [90278-01-6] may be prepared by the reaction of sodium borohydrice with perfluoro-2-methyl-2-pentene as disclosed by Snegirev, et. al. in Izx. Akad. Nauk SSSR, Ser. Khim., pp. 2775-2781 (1983).

As early as the 1970's with the initial emergence of a theory that the ozone was being depleted by chlorine atoms introduced to the atmosphere from the release of fully halogenated chlorofluorocarbons, it was known that the introduction

of hydrogen into previously fully halogenated chlorofluorocarbons markedly reduced the chemical stability of these compounds. Hence, these now destabilized compounds would be expected to degrade in the atmosphere and not reach the stratosphere and the ozone layer.

Ozone Depletion Potential (ODP) is based on the ratio of the calculated ozone depletion in the stratosphere resulting from the emission of a compound compared to the ozone depletion potential resulting from the same rate of emission of CFC-11, which is set at 1.0. Compounds of the present invention do not contain any chlorine or bromine and therefore have an Ozone Depletion Potential (ODP) of 0 as compared with CFC-113 at 0.8.

Although compounds of the present invention have zero ODP and an expected lower global warming potential than CFCs, they are extremely effective refrigerants and perform similarly to chlorofluorocarbon refrigerants.

Another important consideration when selecting a refrigerant is the stability of the compound under consideration. Compounds are usually preferred that do not contain groups which may eliminate hydrogen fluoride during use. Examples of groups where hydrogen fluoride may be eliminated include $-CH_2CH_2F$ and $-CH_2-CHF-CH_2-$ (see Powell, U.S. 4,541,943, column 2, lines 5-9).

There are three important considerations in selecting or designing a centrifugal compressor: the diameter of the impeller, which means the length from the end of one of the impeller blades to the end of an opposite blade, the width of the passage in the impeller, and the refrigerant. The impeller and refrigerant must be selected in a combination that best suits a desired application.

The diameter of the impeller depends on the discharge pressure that must be achieved. For a given rotative speed, a large impeller diameter provides a higher tip speed, which results in a higher pressure ratio. Tip speed means the tangential velocity of the refrigerant leaving the impeller.

If a small turbine centrifugal compressor is driven by an electric motor operating at 40,000 rpm, the impeller diameter needed for the 146.3 m/s tip speed of CFC-113 is about 0.0698 meters.

It is desirable to find a "close match" replacement for CFC-113. By "close match", it is meant a refrigerant that may be used in equipment designed for CFC-113 or that performs similarly to CFC-113. To perform as well as CFC-113, a refrigerant must be such that when it is used, the impeller achieves a tip speed that is comparable to the tip speed of the impeller when CFC-113 is used. Compounds

of the present invention provide tip speed comparable to the tip speed of CFC-113 when the refrigerants are used at the same operating conditions.

The liquid density of the refrigerant is another important design characteristic. Approximate liquid densities of the compounds of the present invention are all within about +/- 25 percent of CFC-113 as shown in Table 1.

TABLE 1

Compound	Liquid Densities (g/cc at 25°C)
CFC-113	1.565
245caEαβ	1.406
245eaE	1.404
338meeEβγ	1.554
338mmzEβγ	1.435
338peEγδ	1.537
347mcfEβγ	1.472
347mcfEγδ	1.473
356mecE2αβγδ	1.476
356mecEγδ	1.443
356mmzEβγ	1.435
365sfEγδ	1.345
374pceEβγ	1.240
383meEβγ	1.121
42-11meEγδ	1.605
467sfEγδ	1.409
467mmyEβγ	1.386
$C_4F_9OCH_3$	1.585
$C_4F_9OC_2H_5$	1.503
c354cc	1.418
c51-12mym	1.783
c51-12c	1.900
FC-51-14	1.670
$C_5F_{11}NO$	1.861
HFC-338mpy	1.545
HFC-338pcc	1.520
HFC-356mcf	1.365
HFC-42-11mmyc	1.621
HFC-42-11p	1.620
HFC-43-10mee	1.566
HFC-43-10mf	1.573
HFC-449mmzf	1.505

HFC-52-13p	1.684
HFC-54-11mmzf	1.555
$(CF_3)_3COH$	1.629

EXAMPLE 1
Tip Speed to Develop Pressure

Tip speed can be estimated by making some fundamental relationships for refrigeration equipment that use centrifugal compressors. The torque an impeller ideally imparts to a gas is defined as

$$T = m^*(v_2{}^*r_2 - v_1{}^*r_1) \quad \text{Equation 1}$$

where

T = torque, N*m
m = mass rate of flow, kg/s
v_2 = tangential velocity of refrigerant leaving impeller, m/s
r_2 = radius of exit impeller, m
v_1 = tangential velocity of refrigerant entering impeller, m/s
r_1 = radius of inlet of impeller, m

Assuming the refrigerant enters the impeller in an essentially radial direction, the tangential component of the velocity v1 = 0, therefore

$$T = m^*v_2{}^*r_2 \qquad \text{Equation 2}$$

The power required at the shaft is the product of the torque and the rotative speed

$$P = T^*w \qquad \text{Equation 3}$$

where

P = power, W
w = rotative speed, rez/s

therefore,

$$P = T^*w = m^*v_2{}^*r_2{}^*w \quad \text{Equation 4}$$

At low refrigerant flow rates, the tip speed of the impeller and the tangential velocity of the refrigerant are nearly identical; therefore

$$r_2{}^*w = v_2 \qquad \text{Equation 5}$$

and

$$P = m^*v_2{}^*v_2 \qquad \text{Equation 6}$$

Another expression for ideal power is the product of the mass rate of flow and the isentropic work of compression,

$$P = m^*H_i^*(1000J/kJ) \quad \text{Equation 7}$$

where

H_i = Difference in enthalpy of the refrigerant from a saturated vapor at the evaporating conditions to saturated condensing conditions, kJ/kg.

Combining the two expressions Equation 6 and 7 produces,

$$v_2{}^*v_2 = 1000^*H_i \qquad \text{Equation 8}$$

Although equation 8 is based on some fundamental assumptions, it provides a good estimate of the tip speed of the impeller and provides an important way to compare tip speeds of refrigerants.

Table 2 shows theoretical tip speeds that are calculated for 1,2,2-trichlorotrifluoroethane (CFC-113), compounds of the present invention, and ammonia. The conditions assumed for this comparison are:

Evaporator temperature	40.0°F (4.4°C)
Condenser temperature	110.0°F (43.3°C)
Liquid subcool temperature	10.0°F (5.5°C)
Return gas temperature	75.0°F (23.8°C)
Compressor efficiency is	70%

These are typical conditions under which small turbine centrifugal compressors perform.

TABLE 2

Impeller Diameter Calculations at 40,000 rpm

	Hi Btu/lb	Impell. Hi*.7 Btu/lb	Impell. Hi*.7 (KJ/kg)	V2 (m/s)	Diameter (m)	Diameter (in)
CFC-113	13.2	9.2	21.4	146.3	0.0698	2.75
245caEαβ	16.6	11.6	27.0	164.0	0.0783	3.08
245eaE	18.1	12.7	29.4	171.2	0.0817	3.22
338meeEβγ	12.0	8.4	19.5	139.3	0.0665	2.62
338mmzEβγ	11.5	8.1	18.7	136.8	0.0653	2.57

338peEγδ	11.7	8.2	19.0	137.8	0.0658	2.59
347mcfEβγ	12.8	8.9	20.7	143.9	0.0687	2.70
347mcfEγδ	12.8	9.0	20.8	144.2	0.0688	2.71
356mecE2αβγδ	14.0	9.8	22.7	150.7	0.0719	2.83
356mecEγδ	14.5	10.1	23.5	153.3	0.0732	2.88
356mmzEβγ	14.1	9.9	22.9	151.0	0.0721	2.84
365sfEγδ	15.3	10.7	24.8	157.5	0.0752	2.96
374pcEβγ	18.2	12.7	29.6	171.8	0.0820	3.23
383mEβγ	20.1	14.1	32.7	180.9	0.0863	3.40
42-11meEγδ	8.7	6.1	14.1	118.7	0.0567	2.23
467sfEγδ	12.1	8.5	19.7	140.2	0.0669	2.63
467mmyEβγ	11.7	8.2	19.0	137.8	0.0658	2.59
$C_4F_9OCH_3$	10.7	7.5	17.4	131.9	0.0630	2.48
$C_4F_9OC_2H_5$	11.0	7.7	17.8	133.4	0.0637	2.51
c354cc	18.3	12.8	29.7	172.3	0.0822	3.24
c51-12c	7.9	5.5	12.8	113.2	0.0540	2.13
c51-12mym	7.7	5.4	12.5	111.8	0.0534	2.10
FC-51-14	7.8	5.4	12.6	112.3	0.0536	2.11
$C_5F_{11}NO$	8.3	5.8	13.5	115.8	0.0553	2.18
HFC-338mpy	12.8	9.0	20.8	144.2	0.0688	2.71
HFC-338pcc	12.1	8.5	19.6	140.0	0.0668	2.63
HFC-356mcf	14.6	10.2	23.7	153.9	0.0735	2.89
HFC-42-11mmyc	9.1	6.4	14.8	121.6	0.0580	2.28
HFC-42-11p	9.1	6.3	14.7	121.3	0.0579	2.28
HFC-43-10mee	10.3	7.2	16.7	128.8	0.0615	2.42
HFC-43-10mf	9.8	6.8	15.9	126.0	0.0601	2.37
HFC-449mmzf	10.9	7.6	17.7	133.1	0.0635	2.50
HFC-52-13	8.8	6.2	14.3	119.2	0.0569	2.24
HFC-54-11mmzf	9.7	6.8	15.7	125.2	0.0598	2.35
$(CF_3)_3COH$	12.2	8.5	19.8	140.7	0.0672	2.64
NH_3	119.4	83.6	193.9	440.5	0.2102	8.28

Example 1 shows that compounds of the present invention have impeller diameters within +/- 25 percent of CFC-113.

If another refrigerant such as ammonia were used in the equipment designed for CFC-113, the equipment would require an impeller diameter of 0.2102

meters. Therefore, ammonia could not be used in equipment designed for CFC-113 because the impeller diameter of that equipment would need to be increased to 0.2102 meters for the equipment to perform as well with ammonia as it performs with CFC-113.

TABLE 3
Small Turbine Performance Data

The following table shows the performance of various refrigerants. The data are based on the following conditions.

Evaporator temperature	40.0°F (4.4°C)
Condenser temperature	110.0°F (43.3°C)
Subcool temperature	10.0°F (5.5°C)
Return gas temperature	75.0°F (23.8°C)
Compressor efficiency is	70%

Refrig. Comp.	Evap. Press. Psia	(kPa)	Cond. Press. Psia	(kPa)	Comp. Dis. Temp. °F	(°C)	COP	Capacity BTU/min	(kw)
CFC-113	2.7	19	12.8	88	156.3	69.1	4.18	14.8	0.26
245caEαβ	3.3	23	16.5	114	159.2	70.7	4.18	21.6	0.38
245eaE	1.9	13	10.3	71	168.0	75.6	4.25	13.2	0.23
338meeEβγ	2.2	15	11.8	81	141.7	60.9	4.05	14.2	0.25
338mmzEβγ	3.1	21	15.6	108	139.8	59.9	4.00	19.0	0.33
338peEγδ	2.8	19	14.3	99	140.3	60.2	4.02	17.4	0.31
347mcfEβγ	2.7	19	13.8	95	142.0	61.1	4.04	16.9	0.30
347mcfEγδ	2.6	18	13.6	94	142.1	61.2	4.04	16.6	0.29
356mecE2αβγδ	1.5	10	8.7	60	143.8	62.1	4.09	10.3	0.18
356mecEγδ	1.7	12	9.4	65	145.9	63.3	4.12	11.6	0.20
356mmzEβγ	2.2	15	11.6	80	144.3	62.4	4.09	14.5	0.26
365sfEγδ	2.5	17	12.7	88	145.2	62.9	4.10	16.0	0.28
374pcEβγ	1.7	12	9.3	64	152.7	67.1	4.18	11.7	0.21
383mEβγ	2.2	15	11.5	79	152.9	67.2	4.17	14.8	0.26
42-11meEγδ	3.3	23	16.8	116	126.3	52.4	3.75	18.8	0.33
467sfEγδ	2.1	14	11.1	77	133.2	56.2	3.95	13.1	0.23

467mmyEβγ	2.7	19	13.8	95	132.0	55.6	3.91	16.3	0.29
$C_4F_9OCH_3$	1.5	10	8.3	57	131.3	55.2	3.93	9.5	0.17
$C_4F_9OC_2H_5$	0.8	6	5.1	35	128.9	53.8	3.90	5.5	0.10
c354cc	2.6	18	1.7	12	153.1	67.3	4.21	15.9	0.28
c51-12mym	3.1	21	14.0	97	119.7	48.7	3.65	15.9	0.28
c51-12c	2.3	16	10.8	74	120.3	49.1	3.70	12.3	0.22
FC-51-14	1.7	12	9.3	64	121.3	49.6	3.69	10.0	0.18
$C_5F_{11}NO$	2.3	16	11.8	81	122.6	50.3	3.74	13.3	0.23
HFC-338mpy	1.8	12	9.5	66	145.8	63.2	4.12	11.8	0.21
HFC-338pcc	3.0	21	14.4	99	142.8	61.6	4.06	18.2	0.32
HFC-356mcf	3.0	21	14.3	99	145.9	63.3	4.10	18.4	0.32
HFC-42-11mmyc	2.8	19	13.9	96	128.5	53.6	3.83	16.2	0.29
HFC-42-11p	2.8	19	14.2	98	128.4	53.6	3.83	16.5	0.29
HFC-43-10mee	1.9	13	10.4	72	132.8	56.0	3.94	12.2	0.21
HFC-43-10mf	2.6	18	13.1	90	129.5	54.2	3.86	15.5	0.27
HFC-449mmzf	2.1	14	10.8	74	133.5	56.4	3.95	12.8	0.23
HFC-52-13	0.9	6	5.8	40	125.5	51.9	3.82	6.2	0.11
HFC-54-11mmzf	1.2	8	7.2	50	127.1	52.8	3.85	7.9	0.14
$(CF_3)_3COH$	2.3	16	15.0	103	140.6	60.3	3.98	16.4	0.29

Compounds of the present invention could also be used as cleaning agents, aerosol propellants, heat transfer media, gaseous dielectrics, fire extinguishing agents, expansion agents for polymers such as polyolefins and polyurethanes, and power cycle working fluids.

ADDITIONAL COMPOUNDS

Additives such as lubricants, corrosion inhibitors, surfactants, stabilizers, dyes and other appropriate materials may be added to the compositions of the invention for a variety of purposes provided they do not have an adverse influence on the composition for its intended application.

FL-1021

CLAIMS

It is claimed:

1. A composition comprising a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine.

2. The composition of claim 1 comprising 1-(difluoromethoxy)-1,1,2-trifluoroethane, 1-(difluoromethoxy)-1,2,2-trifluoroethane, 1,1'-oxybis(1,2,2,2-tetrafluoro)ethane, 2-(difluoromethoxy)-1,1,1,3,3,3-hexafluoropropane, 3-(difluoromethoxy)1,1,1,2,2,3-hexafluoropropane, 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)-ethane, 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane, 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane, 1,1,1,2,3,3-hexafluoro-3-methoxypropane, 1,1,1,3,3,3-hexafluoro-2-methoxypropane, 1,1,1,2,2-pentafluoro-3-methoxypropane, 1-ethoxy-1,1,2,2-tetrafluoroethane, 2-ethoxy-1,1,1-trifluoroethane, 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)propane, 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane, 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane, 1,1,2,2-tetrafluorocyclobutane, perfluorocyclohexane, 1,1,2,2,3,4-hexafluoro-3,4-bis(trifluoromethyl)cyclobutane, perfluorohexane, perfluoro-n-methylmorpholine, 2-(difluoromethyl)-1,1,1,2,3,3-hexafluoropropane, 1,1,2,2,3,3,4,4-octafluorobutane, 1,1,1,2,2,4-hexafluorobutane, 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane, 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1,1,1,2,2,3,3,5,5,5-decafluoropentane, 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluorohexane, 1,1,1,2,2,5,5,5-octafluoro-4-(trifluoromethyl)pentane, nonafluoro-tert-butanol, 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-methoxy-propane, 1,1,1,3,3,3-hexafluoro-2-methoxy-2-(trifluoromethyl)-propane, 1,1,1,2,3,3,4,4,4-nonafluoro-2-methoxy-butane, 1,1,1,2,2,3,3,4,4-nonafluoro-4-ethoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-ethoxy-propane, 1,1,1,3,3,3-hexafluoro-2-ethoxy-2-(trifluoromethyl)propane, and 1,1,1,2,3,3,4,4,4-nonafluoro-2-ethoxy-butane.

3. The composition of claim 1 or 2 wherein said composition is used as a refrigerant.

4. The composition of claim 1 or 2 wherein said composition is used as an aerosol propellant, a cleaning agent, a heat transfer media, a gaseous dielectric, a fire extinguishing agent, an expansion agent for polymers such as polyolefins and polyurethanes, or as a power cycle working fluid.

5. A refrigerant for use with a centrifugal compressor selected from a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine.

6. The refrigerant of claim 5 wherein the compressor is a small turbine centrifugal compressor.

7. The composition of claim 5 comprising a refrigerant for use with a centrifugal compressor said refrigerant selected from the group consisting of 1-(difluoromethoxy)-1,1,2-trifluoroethane, 1-(difluoromethoxy)-1,2,2-trifluoroethane, 1,1'-oxybis(1,2,2,2-tetrafluoro)ethane, 2-(difluoromethoxy)-1,1,1,3,3,3-hexafluoropropane, 3-(difluoromethoxy)1,1,1,2,2,3-hexafluoropropane, 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)-ethane, 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane, 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane, 1,1,1,2,3,3-hexafluoro-3-methoxypropane, 1,1,1,3,3,3-hexafluoro-2-methoxypropane, 1,1,1,2,2-pentafluoro-3-methoxypropane, 1-ethoxy-1,1,2,2-tetrafluoroethane, 2-ethoxy-1,1,1-trifluoroethane, 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)propane, 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane, 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane, 1,1,2,2-tetrafluorocyclobutane, perfluorocyclohexane, 1,1,2,2,3,4-hexafluoro-3,4-bis(trifluoromethyl)cyclobutane, perfluorohexane, perfluoro-n-methylmorpholine, 2-(difluoromethyl)-1,1,1,2,3,3-hexafluoropropane, 1,1,2,2,3,3,4,4-octafluorobutane, 1,1,1,2,2,4-hexafluorobutane, 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane, 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1,1,1,2,2,3,3,5,5,5-

decafluoropentane, 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluorohexane, 1,1,1,2,2,5,5,5-octafluoro-4-(trifluoromethyl)pentane, nonafluoro-tert-butanol, 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-methoxy-propane, 1,1,1,3,3,3-hexafluoro-2-methoxy-2-(trifluoromethyl)-propane, 1,1,1,2,3,3,4,4,4-nonafluoro-2-methoxy-butane, 1,1,1,2,2,3,3,4,4-nonafluoro-4-ethoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-ethoxy-propane, 1,1,1,3,3,3-hexafluoro-2-ethoxy-2-(trifluoromethyl)propane, and 1,1,1,2,3,3,4,4,4-nonafluoro-2-ethoxy-butane.

8. A process for preparing a polymer foam from a polymer foam formulation utilizing an effective amount of a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine.

9. A process according to claim 8 for preparing a polymer foam from a polymer foam formulation utilizing an effective amount of 1-(difluoromethoxy)-1,1,2-trifluoroethane, 1-(difluoromethoxy)-1,2,2-trifluoroethane, 1,1'-oxybis(1,2,2,2-tetrafluoro)ethane, 2-(difluoromethoxy)-1,1,1,3,3,3-hexafluoropropane, 3-(difluoromethoxy)1,1,1,2,2,3-hexafluoropropane, 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)-ethane, 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane, 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane, 1,1,1,2,3,3-hexafluoro-3-methoxypropane, 1,1,1,3,3,3-hexafluoro-2-methoxypropane, 1,1,1,2,2-pentafluoro-3-methoxypropane, 1-ethoxy-1,1,2,2-tetrafluoroethane, 2-ethoxy-1,1,1-trifluoroethane, 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)propane, 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane, 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane, 1,1,2,2-tetrafluorocyclobutane, perfluorocyclohexane, 1,1,2,2,3,4-hexafluoro-3,4-bis(trifluoromethyl)cyclobutane, perfluorohexane, perfluoro-n-methylmorpholine, 2-(difluoromethyl)-1,1,1,2,3,3-hexafluoropropane, 1,1,2,2,3,3,4,4-octafluorobutane, 1,1,1,2,2,4-hexafluorobutane, 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane, 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1,1,1,2,2,3,3,5,5,5-decafluoropentane, 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluorohexane, 1,1,1,2,2,5,5,5-

octafluoro-4-(trifluoromethyl)pentane, nonafluoro-tert-butanol, 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-methoxy-propane, 1,1,1,3,3,3-hexafluoro-2-methoxy-2-(trifluoromethyl)-propane, 1,1,1,2,3,3,4,4,4-nonafluoro-2-methoxy-butane, 1,1,1,2,2,3,3,4,4-nonafluoro-4-ethoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-ethoxy-propane, 1,1,1,3,3,3-hexafluoro-2-ethoxy-2-(trifluoromethyl)propane, and 1,1,1,2,3,3,4,4,4-nonafluoro-2-ethoxy-butane.

10. A process for preparing an aerosol utilizing an effective amount of a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine.

11. A process according to claim 10 for preparing an aerosol utilizing an effective amount of 1-(difluoromethoxy)-1,1,2-trifluoroethane, 1-(difluoromethoxy)-1,2,2-trifluoroethane, 1,1′-oxybis(1,2,2,2-tetrafluoro)ethane, 2-(difluoromethoxy)-1,1,1,3,3,3-hexafluoropropane, 3-(difluoromethoxy)1,1,1,2,2,3-hexafluoropropane, 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)-ethane, 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane, 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane, 1,1,1,2,3,3-hexafluoro-3-methoxypropane, 1,1,1,3,3,3-hexafluoro-2-methoxypropane, 1,1,1,2,2-pentafluoro-3-methoxypropane, 1-ethoxy-1,1,2,2-tetrafluoroethane, 2-ethoxy-1,1,1-trifluoroethane, 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)propane, 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane, 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane, 1,1,2,2-tetrafluorocyclobutane, perfluorocyclohexane, 1,1,2,2,3,4-hexafluoro-3,4-bis(trifluoromethyl)cyclobutane, perfluorohexane, perfluoro-n-methylmorpholine, 2-(difluoromethyl)-1,1,1,2,3,3-hexafluoropropane, 1,1,2,2,3,3,4,4-octafluorobutane, 1,1,1,2,2,4-hexafluorobutane, 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane, 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1,1,1,2,2,3,3,5,5,5-decafluoropentane, 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluorohexane, 1,1,1,2,2,5,5,5-octafluoro-4-(trifluoromethyl)pentane, nonafluoro-tert-butanol, 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-methoxy-propane,

1,1,1,3,3,3-hexafluoro-2-methoxy-2-(trifluoromethyl)-propane, 1,1,1,2,3,3,4,4,4-nonafluoro-2-methoxy-butane, 1,1,1,2,2,3,3,4,4-nonafluoro-4-ethoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-ethoxy-propane, 1,1,1,3,3,3-hexafluoro-2-ethoxy-2-(trifluoromethyl)propane, and 1,1,1,2,3,3,4,4,4-nonafluoro-2-ethoxy-butane.

12. A process for atomizing a fluid comprising using a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine.

13. A process according to claim 12 for atomizing a fluid comprising using 1-(difluoromethoxy)-1,1,2-trifluoroethane, 1-(difluoromethoxy)-1,2,2-trifluoroethane, 1,1'-oxybis(1,2,2,2-tetrafluoro)ethane, 2-(difluoromethoxy)-1,1,1,3,3,3-hexafluoropropane, 3-(difluoromethoxy)1,1,1,2,2,3-hexafluoropropane, 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)-ethane, 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane, 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane, 1,1,1,2,3,3-hexafluoro-3-methoxypropane, 1,1,1,3,3,3-hexafluoro-2-methoxypropane, 1,1,1,2,2-pentafluoro-3-methoxypropane, 1-ethoxy-1,1,2,2-tetrafluoroethane, 2-ethoxy-1,1,1-trifluoroethane, 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)propane, 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane, 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane, 1,1,2,2-tetrafluorocyclobutane, perfluorocyclohexane, 1,1,2,2,3,4-hexafluoro-3,4-bis(trifluoromethyl)cyclobutane, perfluorohexane, perfluoro-n-methylmorpholine, 2-(difluoromethyl)-1,1,1,2,3,3-hexafluoropropane, 1,1,2,2,3,3,4,4-octafluorobutane, 1,1,1,2,2,4-hexafluorobutane, 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane, 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1,1,1,2,2,3,3,5,5,5-decafluoropentane, 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluorohexane, 1,1,1,2,2,5,5,5-octafluoro-4-(trifluoromethyl)pentane, nonafluoro-tert-butanol, 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-methoxy-propane, 1,1,1,3,3,3-hexafluoro-2-methoxy-2-(trifluoromethyl)-propane, 1,1,1,2,3,3,4,4,4-nonafluoro-2-methoxy-butane, 1,1,1,2,2,3,3,4,4-nonafluoro-4-ethoxy-butane,

1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-ethoxy-propane, 1,1,1,3,3,3-hexafluoro-2-ethoxy-2-(trifluoromethyl)propane, and 1,1,1,2,3,3,4,4,4-nonafluoro-2-ethoxy-butane.

14. A process for electrically insulating comprising using a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine.

15. A process according to claim 14 for electrically insulating comprising a step of using 1-(difluoromethoxy)-1,1,2-trifluoroethane, 1-(difluoromethoxy)-1,2,2-trifluoroethane, 1,1′-oxybis(1,2,2,2-tetrafluoro)ethane, 2-(difluoromethoxy)-1,1,1,3,3,3-hexafluoropropane, 3-(difluoromethoxy)1,1,1,2,2,3-hexafluoropropane, 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)-ethane, 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane, 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane, 1,1,1,2,3,3-hexafluoro-3-methoxypropane, 1,1,1,3,3,3-hexafluoro-2-methoxypropane, 1,1,1,2,2-pentafluoro-3-methoxypropane, 1-ethoxy-1,1,2,2-tetrafluoroethane, 2-ethoxy-1,1,1-trifluoroethane, 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)propane, 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane, 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane, 1,1,2,2-tetrafluorocyclobutane, perfluorocyclohexane, 1,1,2,2,3,4-hexafluoro-3,4-bis(trifluoromethyl)cyclobutane, perfluorohexane, perfluoro-n-methylmorpholine, 2-(difluoromethyl)-1,1,1,2,3,3-hexafluoropropane, 1,1,2,2,3,3,4,4-octafluorobutane, 1,1,1,2,2,4-hexafluorobutane, 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane, 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1,1,1,2,2,3,3,5,5,5-decafluoropentane, 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluorohexane, 1,1,1,2,2,5,5,5-octafluoro-4-(trifluoromethyl)pentane, nonafluoro-tert-butanol, 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-methoxy-propane, 1,1,1,3,3,3-hexafluoro-2-methoxy-2-(trifluoromethyl)-propane, 1,1,1,2,3,3,4,4,4-nonafluoro-2-methoxy-butane, 1,1,1,2,2,3,3,4,4-nonafluoro-4-ethoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-ethoxy-propane, 1,1,1,3,3,3-hexafluoro-2-ethoxy-2-(trifluoromethyl)propane, and 1,1,1,2,3,3,4,4,4-nonafluoro-2-ethoxy-butane as a gaseous dielectric.

16. A process for suppressing a fire comprising using a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine.

17. A process according to claim 16 for suppressing a fire comprising a step of using 1-(difluoromethoxy)-1,1,2-trifluoroethane, 1-(difluoromethoxy)-1,2,2-trifluoroethane, 1,1′-oxybis(1,2,2,2-tetrafluoro)ethane, 2-(difluoromethoxy)-1,1,1,3,3,3-hexafluoropropane, 3-(difluoromethoxy)1,1,1,2,2,3-hexafluoropropane, 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)-ethane, 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane, 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane, 1,1,1,2,3,3-hexafluoro-3-methoxypropane, 1,1,1,3,3,3-hexafluoro-2-methoxypropane, 1,1,1,2,2-pentafluoro-3-methoxypropane, 1-ethoxy-1,1,2,2-tetrafluoroethane, 2-ethoxy-1,1,1-trifluoroethane, 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)propane, 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane, 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane, 1,1,2,2-tetrafluorocyclobutane, perfluorocyclohexane, 1,1,2,2,3,4-hexafluoro-3,4-bis(trifluoromethyl)cyclobutane, perfluorohexane, perfluoro-n-methylmorpholine, 2-(difluoromethyl)-1,1,1,2,3,3-hexafluoropropane, 1,1,2,2,3,3,4,4-octafluorobutane, 1,1,1,2,2,4-hexafluorobutane, 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane, 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1,1,1,2,2,3,3,5,5,5-decafluoropentane, 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluorohexane, 1,1,1,2,2,5,5,5-octafluoro-4-(trifluoromethyl)pentane, nonafluoro-tert-butanol, 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-methoxy-propane, 1,1,1,3,3,3-hexafluoro-2-methoxy-2-(trifluoromethyl)-propane, 1,1,1,2,3,3,4,4,4-nonafluoro-2-methoxy-butane, 1,1,1,2,2,3,3,4,4-nonafluoro-4-ethoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-ethoxy-propane, 1,1,1,3,3,3-hexafluoro-2-ethoxy-2-(trifluoromethyl)propane, and 1,1,1,2,3,3,4,4,4-nonafluoro-2-ethoxy-butane as a fire extinguishing agent.

18. A process for delivering power comprising using a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$ wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine.

19. A process according to claim 18 for delivering power comprising using 1-(difluoromethoxy)-1,1,2-trifluoroethane, 1-(difluoromethoxy)-1,2,2-trifluoroethane, 1,1′-oxybis(1,2,2,2-tetrafluoro)ethane, 2-(difluoromethoxy)-1,1,1,3,3,3-hexafluoropropane, 3-(difluoromethoxy)1,1,1,2,2,3-hexafluoropropane, 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)-ethane, 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane, 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane, 1,1,1,2,3,3-hexafluoro-3-methoxypropane, 1,1,1,3,3,3-hexafluoro-2-methoxypropane, 1,1,1,2,2-pentafluoro-3-methoxypropane, 1-ethoxy-1,1,2,2-tetrafluoroethane, 2-ethoxy-1,1,1-trifluoroethane, 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)propane, 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane, 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane, 1,1,2,2-tetrafluorocyclobutane, perfluorocyclohexane, 1,1,2,2,3,4-hexafluoro-3,4-bis(trifluoromethyl)cyclobutane, perfluorohexane, perfluoro-n-methylmorpholine, 2-(difluoromethyl)-1,1,1,2,3,3-hexafluoropropane, 1,1,2,2,3,3,4,4-octafluorobutane, 1,1,1,2,2,4-hexafluorobutane, 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane, 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1,1,1,2,2,3,3,5,5,5-decafluoropentane, 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluorohexane, 1,1,1,2,2,5,5,5-octafluoro-4-(trifluoromethyl)pentane, nonafluoro-tert-butanol, 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-methoxy-propane, 1,1,1,3,3,3-hexafluoro-2-methoxy-2-(trifluoromethyl)-propane, 1,1,1,2,3,3,4,4,4-nonafluoro-2-methoxy-butane, 1,1,1,2,2,3,3,4,4-nonafluoro-4-ethoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-ethoxy-propane, 1,1,1,3,3,3-hexafluoro-2-ethoxy-2-(trifluoromethyl)propane, and 1,1,1,2,3,3,4,4,4-nonafluoro-2-ethoxy-butane as a power cycle working fluid.

20. A process for cleaning a solid surface comprises treating said surface with a hydrofluoroether or fluoroether of the formula $C_aF_bH_{2a+2-b}O_c$

wherein a = 3 to 6, b = 1 to 14 and c = 1 or 2; an acyclic hydrofluorocarbon or fluorocarbon of the formula $C_dF_eH_{2d+2-e}$ wherein d = 4 to 6 and e = 1 to 14; a cyclic hydrofluorocarbon or fluorocarbon of the formula $C_mF_nH_{2m-n}$ wherein m = 4 to 6 and n = 1 to 12; a fluoroalcohol of the formula $C_rF_sH_{2r+1-s}OH$ wherein r = 4 to 6 and s = 1 to 13; or perfluoro-n-methylmorpholine.

21. A process according to claim 20 for cleaning a solid surface comprises treating said surface with 1-(difluoromethoxy)-1,1,2-trifluoroethane, 1-(difluoromethoxy)-1,2,2-trifluoroethane, 1,1'-oxybis(1,2,2,2-tetrafluoro)ethane, 2-(difluoromethoxy)-1,1,1,3,3,3-hexafluoropropane, 3-(difluoromethoxy)1,1,1,2,2,3-hexafluoropropane, 1,1,2,2-tetrafluoro-1-(2,2,2-trifluoroethoxy)-ethane, 3-difluoromethoxy-1,1,1,2,2-pentafluoropropane, 1,1,2-trifluoro-1-methoxy-2-(trifluoromethoxy)ethane, 1,1,1,2,3,3-hexafluoro-3-methoxypropane, 1,1,1,3,3,3-hexafluoro-2-methoxypropane, 1,1,1,2,2-pentafluoro-3-methoxypropane, 1-ethoxy-1,1,2,2-tetrafluoroethane, 2-ethoxy-1,1,1-trifluoroethane, 1,1,1,2,2,3,3-heptafluoro-3-(1,2,2,2-tetrafluoroethoxy)propane, 3-ethoxy-1,1,1,2,2,3,3-heptafluoropropane, 2-ethoxy-1,1,1,2,3,3,3-heptafluoropropane, 1,1,2,2-tetrafluorocyclobutane, perfluorocyclohexane, 1,1,2,2,3,4-hexafluoro-3,4-bis(trifluoromethyl)cyclobutane, perfluorohexane, perfluoro-n-methylmorpholine, 2-(difluoromethyl)-1,1,1,2,3,3-hexafluoropropane, 1,1,2,2,3,3,4,4-octafluorobutane, 1,1,1,2,2,4-hexafluorobutane, 1,1,1,2,3,3,4,4-octafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5-undecafluoropentane, 1,1,1,2,3,4,4,5,5,5-decafluoropentane, 1,1,1,2,2,3,3,5,5,5-decafluoropentane, 1,1,1,4,4,4-hexafluoro-2-(trifluoromethyl)butane, 1,1,1,2,2,3,3,4,4,5,5,6,6-tridecafluorohexane, 1,1,1,2,2,5,5,5-octafluoro-4-(trifluoromethyl)pentane, nonafluoro-tert-butanol, 1,1,1,2,2,3,3,4,4-nonafluoro-4-methoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-methoxy-propane, 1,1,1,3,3,3-hexafluoro-2-methoxy-2-(trifluoromethyl)-propane, 1,1,1,2,3,3,4,4,4-nonafluoro-2-methoxy-butane, 1,1,1,2,2,3,3,4,4-nonafluoro-4-ethoxy-butane, 1,1,1,2,3,3-hexafluoro-2-(trifluoromethyl)-3-ethoxy-propane, 1,1,1,3,3,3-hexafluoro-2-ethoxy-2-(trifluoromethyl)propane, and 1,1,1,2,3,3,4,4,4-nonafluoro-2-ethoxy-butane.

INTERNATIONAL SEARCH REPORT

International Application No
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A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C09K5/04 C09K3/30 C08J9/14 C11D7/50 C23G5/028

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C09K C08J C11D C23G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO,A,93 24586 (DU PONT DE NEMOURS) 9 December 1993 see abstract; claims 1,2,4; example 1; table 2 ---	1-21
Y	WO,A,94 26837 (E.I. DU PONT DE NE MOURS) 24 November 1994 see abstract; claims 1,4-6; figure 28 ---	1-21
Y	WO,A,93 11201 (UNITED STATES ENVIRONMENTAL PROTECTION AGENCY) 10 June 1993 see abstract; claims 1-58; examples 4-6 see page 10, line 23 - page 11, line 11 ---	1-21
Y	WO,A,94 29402 (DU PONT DE NEMOURS) 22 December 1994 see abstract; claims 1,3-6; figure 1 see page 2, line 25 - page 3, line 7 --- -/--	1-21

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Name and mailing address of the ISA
European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax: (+31-70) 340-3016

Authorized officer
Nicolas, H

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	DATABASE WPI Week 8652 Derwent Publications Ltd., London, GB; AN 86-342477 XP002012858 & JP,A,01 255 978 (ASAHI GLASS) , 13 November 1986 see abstract ---	1-21
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 104 (C-0814) & JP,A,30 000744 (ASAHI GLASS), 7 January 1991, see abstract ---	1-21
A	PATENT ABSTRACTS OF JAPAN vol. 16, no. 006 (C-0900) & JP,A,32 031941 (ASAHI GLASS), 15 October 1991, see abstract -----	1-21

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INTERNATIONAL SEARCH REPORT

Information on patent family members

Intern. ..al Application No
PCT/US 96/08921

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO-A-9324586	09-12-93	AU-A- 4250093	30-12-93
		CN-A- 1082088	16-02-94
		EP-A- 0642560	15-03-95
		JP-T- 7507342	10-08-95
WO-A-9426837	24-11-94	US-A- 5484546	16-01-96
		AU-A- 6916894	12-12-94
		EP-A- 0699222	06-03-96
WO-A-9311201	10-06-93	AU-B- 668534	09-05-96
		AU-A- 3151393	28-06-93
		CA-A- 2125143	10-06-93
		CN-A- 1075977	08-09-93
		EP-A- 0615538	21-09-94
		JP-T- 7504889	01-06-95
WO-A-9429402	22-12-94	US-A- 5480572	02-01-96
		AU-A- 7204394	03-01-95
		EP-A- 0703953	03-04-96